

What is claimed is:

1           1.       A method for removing contaminants from the surface of a substrate which  
2           comprises applying a fluid to the surface; lowering the temperature of the fluid so as to form  
3           a solid layer of the fluid over the surface and entrapping contaminants within the layer; and  
4           applying energy to the layer or substrate or both under such conditions as to result in  
5           separation of the layer including the contaminants from the surface.

1           2.       The method of claim 1 wherein the substrate is a semiconductor substrate.

1           3.       The method of claim 1 wherein the substrate is a silicon substrate.

1           4.       The method of claim 1 wherein the contaminants comprise silicon, silicates,  
2           silicon dioxide, metals, metal oxides, organic materials, and bacteria.

1           5.       The method of claim 1 wherein the fluid comprises water.

1           6.       The method of claim 5 wherein the water is deionized water.

1           7.       The method of claim 1 wherein the energy is applied to the layer.

2           8.       The method of claim 1 wherein the energy is applied to the substrate.

3           9.       The method of claim 1 wherein the fluid is applied at ambient conditions.

1           10.      The method of claim 1 wherein the temperature of the fluid is lowered by  
2           directly reducing its temperature.

1           11.      The method of claim 1 wherein the temperature of the fluid is lowered by  
2           employing a cryogenic gas in the solid or liquid phase.

1           12.      The method of claim 11 wherein said cryogenic gas comprises nitrogen.

Sub 91

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13. The method of claim 11 wherein said cryogenic gas comprises carbon dioxide.

14. The method of claim 1 wherein the energy is sonic energy.

15. The method of claim 14 wherein the sonic energy is applied to the layer.

16. The method of claim 14 wherein the sonic energy is applied to the substrate.

17. The method of claim 1 wherein heat energy is applied.

18. The method of claim 17 wherein the heat energy is applied to the substrate.

19. The method of claim 1 wherein the temperature of the fluid is lowered by reducing the temperature of the substrate.

20. The method of claim 19 wherein the temperature of the fluid is lowered by employing a cryogenic gas in the solid or liquid phase.

21. The method of claim 20 wherein said cryogenic gas comprises nitrogen.

22. The method of claim 20 wherein said cryogenic gas comprises carbon dioxide.

23. A method for removing contaminants from the surface of a substrate which comprises applying a fluid to the surface; lowering the temperature of the fluid by reducing the temperature of the substrate so as to form a solid layer of the fluid over the surface and entrapping contaminants within the layer; and applying sonic energy to the layer or substrate

5 or both under such conditions as to result in separation of the layer including the  
6 contaminants from the surface.

Sub 91

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24. The method of claim 23 wherein the substrate is a semiconductor substrate.

25. The method of claim 23 wherein the substrate is a silicon substrate.

26. The method of claim 23 wherein the contaminants comprise silicon, silicates,  
silicon dioxide, metals, metal oxides, organic materials, and bacteria.

27. The method of claim 23 wherein the fluid comprises water.

28. The method of claim 27 wherein the water is deionized water.

29. The method of claim 27 wherein the fluid is applied at ambient conditions.

30. The method of claim 23 wherein the sonic energy is applied to the layer.

31. The method of claim 23 wherein the sonic energy is applied to the substrate.

32. The method of claim 23 wherein the temperature of the fluid is lowered by  
employing a cryogenic gas in the solid or liquid phase.

33. The method of claim 32 wherein said cryogenic gas comprises nitrogen.

34. The method of claim 32 wherein said cryogenic gas comprises carbon  
dioxide.

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